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- 6 In accordance with the present invention, a monolithic
- 7 construction novel food container 1, which can be heated in
- 8 a microwave oven without distortion of its shape, without
- 9 interfering with or overloading the microwave energy beam
- 10 or the microwave radiant energy generation unit and without
- 11 leakage even when the contained food reaches a boiling
- 12 point, i.e., a temperature near 100 degrees Celsius,
- 13 comprises;
- 14 an impermeable cavity 2 defined by i) a continuous seamless
- 15 wall 3 with a periphery 4, said periphery having no folded
- 16 gussets and is preferably polygonal in shape, for example
- 17 rectangular, pentagonal, hexagonal or octagonal. Said
- 18 periphery also having a top peripheral portion 5 and a
- 19 bottom peripheral portion 6, and ii) a bottom surface 7,
- 20 said bottom surface being hermetically, and preferably
- 21 seamlessly or integrally, joined to said bottom peripheral
- 22 portion 6 thereby forming the impermeable cavity 2, said
- 23 wall and said bottom surface being made of a thermoplastic
- 24 polymeric material, a set of at least two flaps 8, said

- 1 flaps being joined, and preferably integrally and
- 2 seamlessly, to said top peripheral portion 5 at joining
- 3 lines 9 located on said top peripheral portion, said flaps
- 4 being made of same said thermoplastic polymeric material,
- 5 said joining lines 9 being adapted to form flexural, and
- 6 preferably living, hinges along substantially straight
- 7 lines, said thermoplastic polymeric material having a glass
- 8 transition temperature of at least -(negative) 20 degrees
- 9 Celsius and/or a Heat Distortion Temperature , measured
- 10 under a stress of 264 psi, in accordance with ASTM Standard
- 11 Method No. D648, of at least 48 degrees Celsius, thereby
- 12 enabling said container to contain food and sustain heating
- 13 in a microwave oven without distortion of its shape,
- 14 without interfering with or overloading the radiant energy
- 15 generation unit and without leakage. Preferred examples of
- 16 such thermoplastic polymeric materials are polypropylene
- 17 and polystyrene.
- 18
- 19 As described above, the food container of the present
- 20 invention is made of a thermoplastic polymeric material
- 21 with a Heat Distortion Temperature of at least 48 °C and up
- 22 to 200 °C, (118 °F to 392 °F) including all 1 °C range
- increments in between the range of 48 °C to 200 °C. In other
- 24 words, the ranges of Heat Distortion Temperature

- 1 contemplated in this application are 48°C to 200°C, 49°C to
- 2 199°C, 50°C to 198°C, etc., through 122°C to 124°C. More
- 3 broadly understood by those skilled in the art, is that any
- 4 thermoplastic polymeric material that provides resistance
- 5 to heat and mechanical stress in a microwave heating
- 6 environment without reflecting the radiant energy beam and
- 7 thus avoiding to overload the microwave energy generation
- 8 unit is a thermoplastic polymeric material suitable for use
- 9 in making the food container of the present invention. As
- 10 such, a variety of thermoplastic polymeric materials may be
- 11 used for making the food container of the present
- 12 invention, including; ABS (acrylonitrilebutadienestyrene)
- with HDT of 170° to 220° F, Acetal, with HDT of 253° to 277° F
- 14 , Acrylonitrile With HDT of 151° to 164°F, polyamide
- 15 (including nylon 6, 66 and 610) with HDT of 122° to 185° F,
- 16 polycarbonate with HDT of 250° to 270° F, polyester with HDT
- of 122° to 185°F, Polyimide with HDT of 460° to 680°F,
- 18 polypropylene with HDT of  $120^\circ$  to  $140^\circ$ F , polystyrene with
- 19 HDT of 169 to 202 F and Polyvinylchloride with HDT of 140
- 20 to 170°F.

- 22 The Heat Distortion Temperature referred to above is
- 23 measured by following the test method described in ASTM

- 1 D648 which is a standard test method known to those skilled
- 2 in the art.

- 4 Alternatively, the food container of the present invention
- 5 may be made of a thermoplastic polymeric material with a
- 6 glass transition temperature of at least (negative) 20 °C.

- 8 An example of a material that fulfilled all the above
- 9 conditions and was able to withstand 10 cycles of repeated
- 10 heating in a microwave oven, to a temperature of 100 °C
- 11 while containing boiling water and without distortion,
- 12 shrinkage or leakage is a polypropylene material marketed,
- 13 under the trade name of TOP PLENE P6H-02, by Topping
- 14 Chemical Industries Co., LTD. Of Taiwan . This material was
- 15 injection molded into a food container as described in this
- 16 application. Its Heat Distortion Temperature, as measured
- 17 in accordance with ASTM Test Method No.D648, is 128°C.
- 18 Other grades of polypropylene were also used for making a
- 19 thermoformed food container in accordance with the present
- 20 invention which also yielded similar successful results.
- 21 From a cost, processability, performance and appearance
- 22 standpoints, the most preferred material for implementation
- 23 of the present invention is polypropylene. Polystyrene, and

- 1 in particular impact-modified polystyrene, is also a good
- 2 alternative.

- 4 Other structural features of the present invention are
- 5 presented on the attached drawings which are self
- 6 explanatory. For example, the living hinges located at the
- 7 bases of the handles make it possible to stack a number of
- 8 food containers on top of one another as customarily done
- 9 in the Chinese food service industry.

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- 11 In accordance with the present invention, two methods are
- 12 preferred for producing the food container. These methods
- 13 are injection molding and thermoforming.

- 15 The above described and shown, in the accompanying
- 16 drawings, food container overcomes the performance
- 17 limitations that prior art food containers suffer. An
- 18 example of such prior art food containers is described in
- 19 U.S. Patent No.5,411,204 which is incorporated in this
- 20 application in its entirety by reference. Other related
- 21 U.S. Patents which are incorporated in this application in
- 22 their entirety, by reference are Nos. 5,669,552, 6,206,280,
- 23 5,803,264, 5,855,315, 5,873,220, 6,050,483, 5,947,368,

- 1 5,588,584, 5,484,102, 5,474,231, 5,409,160, 5,351,881,
- 2 5,288,012, 5,060,451, 6,386,441 and 6,189,779.

- 4 The present invention eliminates the need to pre-fold a
- 5 pre-cut cardboard, shape it into a container form and
- 6 attach the four generated folded gussets (one at each
- 7 corner of the rectangle) to the sides of the container, as
- 8 taught, for example in U.S. Patent Nos. 5,411,204 and
- 9 5,873,220. In addition, since no folded gussets are present
- 10 in the container of the present invention, the possibility
- 11 of leakage occurring from the low point of the folded
- 12 gusset (point Q in Figure 3 of U.S. Patent No. 5,873,220,
- 13 (Drawing attached)), it is possible to fill the container
- 14 of the present invention, with liquid and without leakage,
- 15 to a higher level than it is possible to do so with the
- 16 containers taught in the prior art, for example in U.S.
- 17 Patent Nos. 5,411,204 and 5,873,220.

- 19 When the container of the present invention is made by the
- 20 injection molding method, it is preferable that the
- 21 thermoplastic polymeric material used has a melt flow index
- 22 of at least 20 g/10 minutes. The melt flow index, also
- 23 known as the melt flow rate is measured by an experimental
- 24 procedure known to those skilled in the art as ASTM D1238.

- 1 An example of a thermoplastic polymeric material which has
- 2 been used successfully to produce the container of the
- 3 present invention is a polypropylene grade "COSMOPLENE AX
- 4 164" marketed by the tpc company (The Polyolefin Company
- 5 (Singapore) Ltd.). This material has a HDT of 122 C and a
- 6 melt flow rate (melt index) of 50 gm/10 minutes.

- 8 In accordance with the present invention, the thickness of
- 9 the wall of the container is preferably within the range of
- 10 0.006" to 0.060" and may be varied within the same
- 11 container wall yet preferably remaining within that range.
- 12 Of course, stiffeners or thicker areas may be integrally
- 13 added to wall 3 in order to enhance the overall rigidity of
- 14 the container. The low limit of the above mentioned range
- 15 is usually possible when the container is manufactured by
- 16 the thermoforming process which yields thickness
- 17 variations among as well as within the various sections of
- 18 the container. Injection molding, however, provides more
- 19 positive control on the wall thickness by adjusting the
- 20 spacing between the two mating/matching halves of the mold
- 21 to produce the desired thickness at every
- 22 zone/segment/portion/point of the container.

- 1 In a thermoformed container produced in accordance with the
- 2 present invention, utilizing a thermoforming grade
- 3 polypropylene sheet of 0.027" thickness, the wall thickness
- 4 varied from 0.006" at the bottom of cavity 2 to 0.016" at
- 5 the top of cavity 2, i.e., near joining line 9.

- 7 In an injection molded container produced in accordance
- 8 with the present invention, a substantially uniform
- 9 container wall thickness of 0.019" was selected and the
- 10 matching mold halves were machined to generate the desired
- 11 spacing (of approximately 0.019") between them. The living
- 12 hinges (at joining lines 9 and crease lines 10) had a lower
- 13 thickness so that any attempt to deflect flaps 8 towards or
- 14 away from the container would result in a fold/bend around
- 15 lines 9 and/or 10. For example, living hinges 9 and crease
- 16 lines 10 of 0.0045" thickness have been utilized in an
- 17 injection molded container made in accordance with the
- 18 present invention. The ratio of stiffness of the areas
- 19 immediately adjacent to lines 9 and 10, in this case, is
- $(0.019/0.0045)^3 = (4.22)^3 = 75.27$ . In accordance with the
- 21 present invention, the ratio of the thickness of joining
- 22 lines 9 and/or crease lines 10 to the thickness of the
- 23 respective areas immediately adjacent to them is not to
- 24 exceed 0.8. As such the ratio of bending rigidity of

- 1 joining line 9 and/or crease line 10 to the bending
- 2 rigidity of the respective areas immediately adjacent to
- 3 them is not exceeding 0.55. As such, joining lines 9 and/or
- 4 crease lines 10 will always have a tendency to direct any
- 5 bending action applied in their respective vicinities to
- 6 readily form a fold line.
- 7 Joining lines 9 and crease lines 10 may also be made more
- 8 readily tearable/frangible by providing perforations,
- 9 micro-perforations, slits or some other structural weakness
- 10 along their lines. It is also preferable to have joining
- 11 lines 9 start and/or end with notched areas in order to
- 12 facilitate the tearing action which an end user may wish to
- do in order to remove/tear off flaps 8 from the cavity
- 14 section 2 of container 1.

- 16 The present invention also teaches two methods for
- 17 manufacturing food containers, featuring the above
- 18 described geometric characteristics and performance
- 19 characteristics. The first method is through the use of
- 20 injection molding and comprises the steps of:
- 21 Providing a thermoplastic polymeric resin injection mold
- 22 comprising a core segment and a cavity segment, said core
- 23 and cavity segments being so shaped as to mate and create a
- 24 space between them in the form of i) a continuous seamless

- 1 periphery, said periphery having no folded gussets and is
- 2 preferably polygonal in shape, for example; square,
- 3 rectangular, pentagonal, hexagonal or octagonal. Said
- 4 periphery also having a top peripheral portion and a bottom
- 5 peripheral portion and ii) a bottom surface, said bottom
- 6 surface being uninterruptedly in continuous spatial
- 7 communication with said bottom peripheral portion, thereby
- 8 creating a space between said core segment and said cavity
- 9 segment in the form of a continuous cavity corresponding to
- 10 cavity 2. Said core segment and said cavity segment being
- 11 further shaped to create a space between them in the form
- 12 of a set of at least two flaps. Said flaps having base ends
- 13 and free ends, said base ends being substantially of the
- 14 same length as two opposite sides of said top peripheral
- 15 portion and being located parallel and adjacent to said two
- 16 opposite sides of said top peripheral portion. Said space
- 17 creating said flaps being connected to said space
- 18 corresponding to said cavity through a restriction zone of
- 19 a spacing not exceeding 0.8 of the spacing corresponding to
- 20 said top peripheral portion and the space corresponding to
- 21 said flap base, thereby creating a space corresponding to a
- 22 fold line connecting the space corresponding to said flap
- 23 base to that corresponding to said top peripheral portion.

- Injecting a molten thermoplastic polmeric material in said 1
- spacing, said thermoplastic material having a glass 2
- 3 transition temperature of at least -(negative) 20 degrees
- 4 Celsius and/or a Heat Distortion Temperature, measured as
- described earlier, of at least 48 degrees Celsius. 5
- Cooling said injected molten thermoplastic polymeric 6
- 7 material thereby solidifying the molten polymeric material
- injected in the above described spacing, opening said mold 8
- 9 and ejecting the formed food container.

12 13

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